INSTITUTE of
HYDROLOGY

MUQDISHO WATER SUPPLY

EXPANSION

STAGE IIA

EXPLORATION AND MODELLING

STUDIES

VOLUME IV

This report is prepared for

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Nairobi

Kenya

by

Institute of Hydrology

Wallingford

Oxon

UK

June 1984

C. GROUNDWATER CHEMISTRY

APPENDIX C GROUNDWATER CHEMISTRY

Duplicate samples were taken during the airlift of the exploratory boreholes and from selected other sites. The samples were filtered to remove any solids and one was acidified to prevent any change in the cation concentrations.

The samples were analysed by IH for major ions and silica. Field determinations of temperature and conductivity (corrected to 25°C) are given in Appendix D.

The tabulated results show the major cations and anions as concentrations in milligrams per litre and milli-equivalents per litre. The water classes given at the foot of each page are the domestic class with class 1 having all constituents within WHO standards and class 3 having one or more constituents exceeding the WHO maximum permissible level. The agricultural class is based on the US Dept of Agriculture system using both the sodium-adsorption ratio (SAR) and electrical conductivity (EC).

Figure C.1 shows the location of all the chemistry sampling points used for the maps in Chapter 5, these include some determinations carried out and reported on in 1980.

Samples of groundwater were also collected for stable isotope determinations. These were carried out by a joint BGS/IH laboratory at Wallingford. Figure C.2 is a location map showing all the places where stable isotope determinations have been carried out.

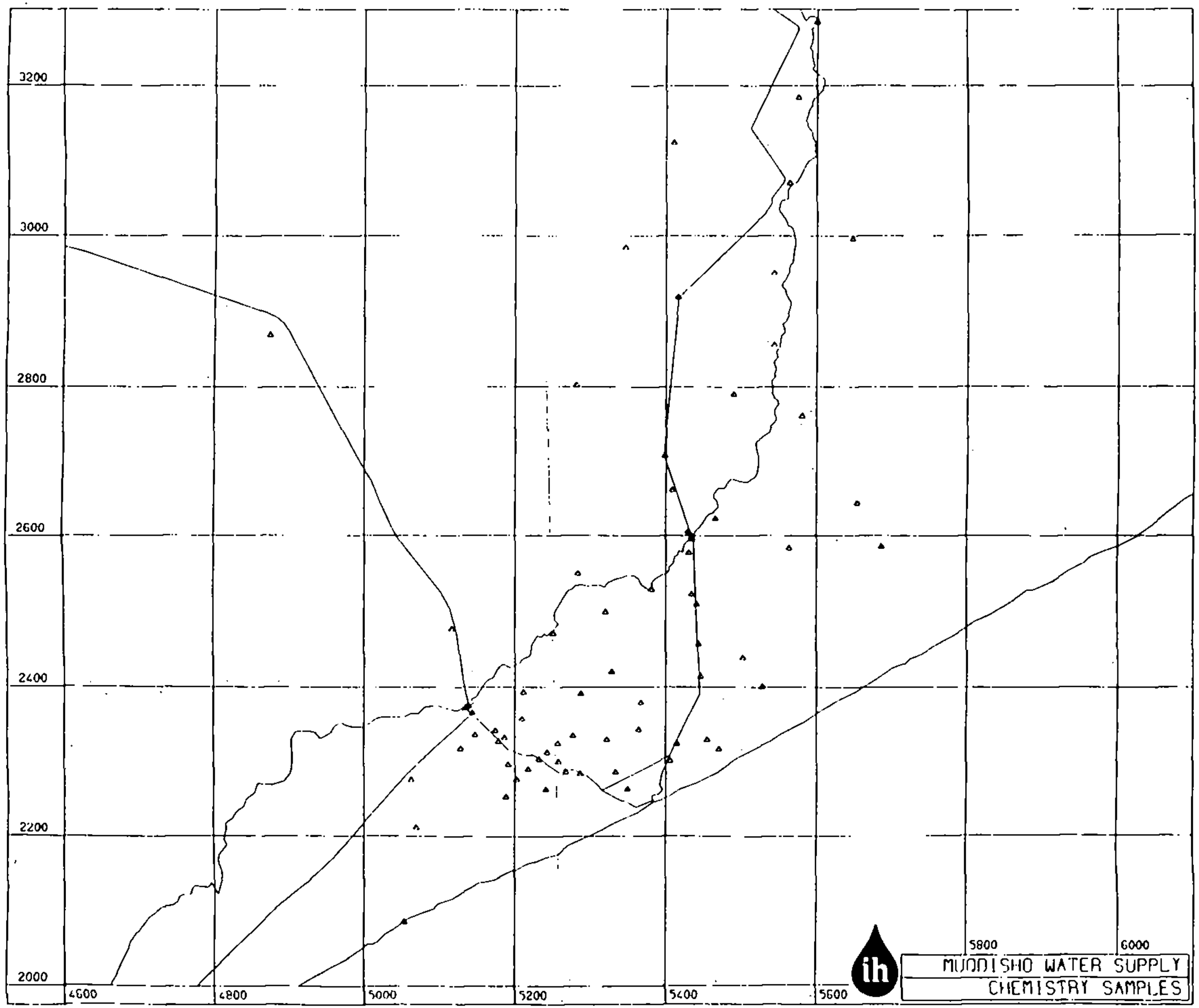
3200
3000
2800
2600
2400
2200
2000
4600
4800
5000
5200
5400
5600
5800
6000
MUDDISHO WATER SUPPLY
CHEMISTRY SAMPLES

Figure C.1

MUQDISHO WATER SUPPLY
CHEMISTRY LOCATION INDEX

GRID REF	WELL	SAMPLE		
48742868	98	30153		
50282630	E012	30250		
50532086	93	30151		
50552275	57	30152		
50642211	E014	30239		
50762561	6	30140		
51162476	5	30139		
51282316	64	30143		
51342372	E96	33		
51362375	RIVER(A)	362		AFGOOYE
51432565	E12	17	*	
51472334	DW2	30101	**	
51742540	E74	23	*	
51762325	E37	36	*	
51862330	E18	35	*	
51862252	DW4	30240	***	
51912295	DW3	30102	**	
52022275	PW32	30231	***	
52042356	MGQ4P	4	*	
52112393	MGQ1T	9358	*	
52172284	DW5	30241	***	
52322302	MGQ2P	2	*	
52412262	DW6	30242	***	
52432311	PW5	30133	**	
52512470	MGQ13P	9360	*	
52572323	PW11	30247	***	
52672285	E34	34	*	
52772333	MGQ5T	11515	*	
52802302	E09TW	30246		
52812802	E09	30201		
52832549	E010	30238		
52862283	MGQ1P	31	*	
52872391	MGQ5P	5	*	
53202498	MGQ11P	11516	*	
53222325	E70	20	*	
53282419	MGQ2T	9359	*	
53332285	E73	24	*	
53462984	89	30154		
53482246	RAIN	8543	*	K4 AFGOOYE RD
53492262	E32	18	*	
53642341	MGQ4T	8545	*	
53672379	SL10T	22	*	
53812528	MGQ6T	11517	*	
53982708	48	30142		
54062300	E55	26		
54082661	55	30141		
54103124	12	30148		
54152322	MGQ3CP	13		

MUQDISHO WATER SUPPLY
CHEMISTRY LOCATION INDEX

GRID REF	WELL	SAMPLE		
54162918	E013	30202		
54302577	E76	27	*	
54302605	E2	38	*	
54342521	E75	19	*	
54342595	E4	5139	*	
54352598	RIVER(B)	8544	*	BALCAD
54412508	E61	15	*	
54442455	MGQ3T	21	*	
54462413	E62	37	*	
54552527	MGQ2CP	12	*	
54662022	19	30146		
54712315	MGQ1CP	11		
54902790	E06	30227		
55022437	MGQ8P	6		
55092515	E011	30245		
55282400	36	30149		
55432855	94	30156		
55422950	E07A	30199		
55422950	E07A	30237		
55432950	E07	30198		
55432950	E07	30236		
55502454	90	30155		
55512457	E63	16		
55632583	E04	30235		
55643070	34	30144		
55753184	85	30147		
55812761	E03	30234		
55943233	93	30145		
56472995	E01	30197		
56542643	E05	30226		
56742750	E02	30232		
56742750	E02	30248		
56862585	E06	30225		
57102539	87	30150		

* 1980 EXPLORATORY STUDY
** 1982 AFGOOYE ROAD WELLFIELD STAGE I
*** 1983 AFGOOYE ROAD WELLFIELD STAGE IIA

MUQDISHO WATER SUPPLY
STAGE IIA DATA
CHEMISTRY SUMMARY

GRID REF		48742868	50282630	50532086	50622275	50692211
WELL NUMBER		98	EO 12	88	57	EO 14
SAMPLE		30153	30250	30151	30152	30239
DATE		11 OCT 82	19 DEC 83	9 OCT 82	11 OCT 82	29 JUL 83
BASIN			.	1	1	1
AQUIFER			1	2	2	2
SOURCE			4	1	1	4
DEPTH						
TOTAL SOLIDS						
ELEC. COND.		5000.	4700.	6580.	3860.	2100.
PH		7.80	7.90	7.70	7.60	8.00
CATIONS	CA	58.	228.	174.	256.	178.
(MG/L)	MG	72.	160.	90.	190.	130.
	NA	900.	640.	1080.	390.	106.
	K	11.	10.	38.	8.	6.
ANIONS	HCO3	471.	300.	565.	372.	305.
(MG/L)	SO4	400.	1250.	700.	1200.	625.
	CL	1220.	740.	1520.	520.	210.
	NO3	5.	<2.0	32.	<1.0	<2.0
CATIONS	CA	2.89	11.38**	8.68*	12.77**	8.88*
(MEQ/L)	MG	5.92*	13.16**	7.40*	15.63**	10.69*
	NA	39.15	27.84	46.98	16.97	4.61
	K	0.28	0.26	0.97	0.20	0.17
ANIONS	HCO3	7.72	4.92	9.26	6.10	5.00
(MEQ/L)	SO4	8.33*	26.02**	14.57**	24.98**	13.01**
	CL	34.40**	20.87**	42.86**	14.66*	5.92*
	NO3	0.08	<.032	0.52	<.016	<.032
SI (MG/L)		15.0		30.0	26.0	22.9
DOMES. CLASS		3	3	3	3	3
AGRIC. CLASS		C4S4	C4S3	C5S4	C4S2	C3S1

* CONCENTRATION EXCEEDS W.H.O. HIGHEST DESIRABLE LEVEL
** CONCENTRATION EXCEEDS W.H.O. MAXIMUM PERMISSIBLE LEVEL

MUQDISHO WATER SUPPLY
STAGE IIA DATA
CHEMISTRY SUMMARY

GRID REF		50762061	51162476	51282316	51382375	52802802
WELL NUMBER		6	5	64	RIVER(A)	EO YTW
SAMPLE		30140	30139	30143	362	30246
DATE		25 SEP 82	25 SEP 82	30 SEP 82	15 AUG 83	12 SEP 83
BASIN				1	1	1
AQUIFER				2	3	1
SOURCE				1	7	8
DEPTH						
TOTAL SOLIDS					350.	
ELEC. COND.		7170.	1920.	1080.	630.	2800.
PH		7.60	7.90	7.90	8.30	7.90
CATIONS	CA	360.	138.	58.	90.	80.
(MG/L)	MG	330.	82.	47.	20.	59.
	NA	800.	180.	120.	22.	498.
	K	5.	5.	2.	5.	7.
ANIONS	HCO3	226.	266.	314.	120.	356.
(MG/L)	SO4	1350.	675.	240.	210.	727.
	CL	1640.	112.	45.	16.	310.
	NO3	<1.0	<1.0	<1.0	0.	<2.0
CATIONS	CA	17.96**	6.89*	2.89	4.47*	3.99*
(MEQ/L)	MG	27.14**	6.74*	3.87	1.66	4.85*
	NA	34.80	7.83	5.22	0.97	21.66
	K	0.13	0.12	0.06	0.12	0.17
ANIONS	HCO3	3.70	4.36	5.15	1.97	5.83
(MEQ/L)	SO4	28.11**	14.05**	5.00*	4.37*	15.14**
	CL	46.25**	3.16	1.27	0.45	8.74*
	NO3	<.016	<.016	<.016	0.	<.032
SI (MG/L)		23.0	20.5	18.0	30.0	15.3
DOMES. CLASS		3	3	2	2	3
AGRIC. CLASS		C5S3	C3S1	C3S1	C2S1	C4S3

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GRID REF		52312802	52832549	53462984	53982708	54082661
WELL NUMBER		EO 9	EO 10	89	48	55
SAMPLE		30201	30238	30154	30142	30141
DATE		8 MAR 83	24 AUG 83	12 OCT 82	29 SEP 82	29 SEP 82
BASIN					1	1
AQUIFER					1	1
SOURCE					1	1
DEPTH						
TOTAL SOLIDS						
ELEC. COND.		2900.	3600.	2040.	3060.	1250.
PH		8.10	7.70	7.80	8.00	8.00
CATIONS	CA	80.	224.	92.	64.	24.
(MG/L)	MG	54.	157.	62.	58.	12.
	NA	470.	369.	260.	550.	240.
	K	7.	10.	5.	2.	3.
ANIONS	HCO3	353.	232.	234.	531.	339.
(MG/L)	SO4	750.	886.	400.	750.	275.
	CL	310.	620.	280.	280.	72.
	NO3	<2.0	4.	<1.0	2.	<1.0
CATIONS	CA	3.99*	11.18**	4.59*	3.19	1.20
(MEQ/L)	MG	4.44*	12.91**	5.10*	4.77*	0.99
	NA	20.45	16.05	11.31	23.93	10.44
	K	0.18	0.25	0.14	0.06	0.07
ANIONS	HCO3	5.79	3.80	3.84	8.70	5.56
(MEQ/L)	SO4	15.62**	18.45**	8.33*	15.62**	5.73*
	CL	8.74*	17.48**	7.90*	7.90*	2.03
	NO3	<.032	0.06	<.016	0.03	<.016
SI (MG/L)		17.2	29.5	16.0	22.0	19.0
DOMES. CLASS		3	3	2	3	2
AGRIC. CLASS		C4S3	C4S2	C3S2	C4S3	C3S2

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** CONCENTRATION EXCEEDS W.H.O. MAXIMUM PERMISSIBLE LEVEL

GRID REF		54103124	54162918	54662622	54902790	55092515
WELL NUMBER		12	EO 13	19	EO 8	EO 11
SAMPLE		30148	30202	30146	30227	30245
DATE		6 OCT 82	22 MAR 83	5 OCT 82	3 APR 83	7 SEP 83
BASIN				1	.	1
AQUIFER				2	1	2
SOURCE				1	4	4
DEPTH						
TOTAL SOLIDS						
ELEC. COND.		5060.	2100.	1150.	3300.	1350.
PH		7.60	8.10	7.90	8.30	8.20
CATIONS	CA	312.	84.	60.	110.	19.
(MG/L)	MG	225.	50.	34.	69.	33.
	NA	460.	290.	135.	530.	272.
	K	15.	6.	4.	8.	5.
ANIONS	HCO3	132.	357.	222.	351.	444.
(MG/L)	SO4	800.	500.	300.	690.	279.
	CL	1220.	170.	62.	410.	50.
	NO3	<1.0	<2.0	<1.0	<2.0	<2.0
CATIONS	CA	15.57**	4.19*	2.99	5.49*	0.95
(MEQ/L)	MG	18.50**	4.11*	2.80	5.67*	2.71
	NA	20.01	12.62	5.87	23.06	11.83
	K	0.39	0.15	0.10	0.20	0.14
ANIONS	HCO3	2.98	5.85	3.64	5.75	7.28
(MEQ/L)	SO4	16.66**	10.41**	6.25*	14.37**	5.81*
	CL	34.40**	4.79	1.75	11.56*	1.41
	NO3	<.016	<.032	<.016	<.032	<.032
SI (MG/L)		16.0	16.4	15.0	21.0	26.7
DOMES. CLASS		3	3	2	3	2
AGRIC. CLASS		C5S2	C3S2	C3S1	C4S3	C3S2

* CONCENTRATION EXCEEDS W.H.O. HIGHEST DESIRABLE LEVEL
** CONCENTRATION EXCEEDS W.H.O. MAXIMUM PERMISSIBLE LEVEL

GRID REF		55282400	55422950	55422950	55432855	55432950
WELL NUMBER		86	ED 7A	ED 7A	94	ED 7
SAMPLE		30149	30199	30237	30156	30198
DATE		8 OCT 82	2 MAR 83	21 AUG 83	14 OCT 82	25 FEB 83
BASIN		1		.	1	
AQUIFER		2		1	1	
SOURCE		2		4	2	
DEPTH						
TOTAL SOLIDS						
ELEC. COND.		5050.	5500.	5400.	2080.	7300.
PH		7.60	7.50	7.80	7.80	7.70
CATIONS	CA	124.	300.	279.	64.	440.
(MG/L)	MG	126.	230.	254.	43.	245.
	NA	900.	700.	747.	340.	750.
	K	10.	3.	4.	5.	16.
ANIONS	HCO3	661.	346.	316.	389.	267.
(MG/L)	SO4	1450.	2100.	2290.	600.	1700.
	CL	675.	500.	490.	118.	1460.
	NO3	3.	8.	14.	16.	<2.0
CATIONS	CA	6.19*	14.97**	13.92**	3.19	21.96**
(MEQ/L)	MG	10.36*	13.92**	20.89**	3.54	20.15**
	NA	39.15	30.45	32.49	14.79	32.63
	K	0.25	0.21	0.10	0.13	0.41
ANIONS	HCO3	10.83	5.67	5.18	6.38	4.38
(MEQ/L)	SO4	30.19**	43.72**	47.68**	12.49**	35.39**
	CL	19.04**	14.10*	13.82*	3.33	41.17**
	NO3	0.05	0.13	0.23	0.26	<.032
SI (MG/L)		50.0	20.4	21.6	35.0	16.3
DOMES. CLASS		3	3	3	3	3
AGRIC. CLASS		C5S4	C5S3	C5S3	C3S2	C5S3

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** CONCENTRATION EXCEEDS W.H.O. MAXIMUM PERMISSIBLE LEVEL

GRID REF		55432950	55502454	55632583	55643070	55753184
WELL NUMBER		EO 7	90	EO 4	34	85
SAMPLE		30236	30155	30235	30144	30147
DATE		16 AUG 83	13 OCT 82	7 JUN 83	3 OCT 82	6 OCT 82
BASIN			1	1	1	
AQUIFER			2	2	1	
SOURCE			1	4	1	
DEPTH						
TOTAL SOLIDS						
ELEC. COND.		7000.	2480.	1150.	3900.	1910.
PH		8.00	7.90	7.90	7.70	7.80
CATIONS	CA	415.	48.	118.	268.	92.
(MG/L)	MG	277.	21.	29.	210.	65.
	NA	812.	460.	38.	370.	245.
	K	12.	4.	9.	3.	3.
ANIONS	HCO3	236.	624.	230.	375.	222.
(MG/L)	SO4	1720.	310.	400.	1450.	700.
	CL	1400.	320.	37.	380.	100.
	NO3	2.	7.	<1.0	7.	1.
CATIONS	CA	20.71**	2.40	5.89*	13.37**	4.59*
(MEQ/L)	MG	22.73**	1.73	2.34	17.27**	5.35*
	NA	35.32	20.01	1.65	16.10	10.66
	K	0.30	0.11	0.24	0.08	0.07
ANIONS	HCO3	3.87	10.23	3.77	6.15	3.64
(MEQ/L)	SO4	35.81**	6.45*	8.33*	30.19**	14.57**
	CL	39.42**	9.02*	1.04	10.72*	2.82
	NO3	0.03	0.11	<.016	0.11	0.02
SI (MG/L)		16.2	27.0	32.0	30.0	18.0
DOMES. CLASS		3	2	2	3	3
AGRIC. CLASS		C5S3	C4S4	C3S1	C4S2	C3S2

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** CONCENTRATION EXCEEDS W.H.O. MAXIMUM PERMISSIBLE LEVEL

MUQDISHO WATER SUPPLY
STAGE IIA DATA
CHEMISTRY SUMMARY

GRID REF		55812761	55993283	56472995	56542643	56742750
WELL NUMBER		EO 3	83	EO 1	EO 5	EO 2
SAMPLE		30234	30145	30197	30226	30248
DATE		31 MAY 83	4 OCT 82	10 FEB 83	19 APR 83	10 OCT 83
BASIN		.			1	1
AQUIFER		2			2	2
SOURCE		4			4	4
DEPTH						
TOTAL SOLIDS						
ELEC. COND.		2200.	1160.	7200.	3100.	1480.
PH		8.10	7.90	8.10	7.90	8.20
CATIONS	CA	106.	72.	340.	84.	38.
(MG/L)	MG	68.	42.	200.	82.	38.
	NA	230.	110.	850.	470.	242.
	K	7.	4.	9.	10.	5.
ANIONS	HCO3	337.	213.	330.	205.	298.
(MG/L)	SO4	700.	300.	1800.	720.	346.
	CL	140.	80.	1280.	370.	107.
	NO3	2.	<1.0	<2.0	2.	<2.0
CATIONS	CA	5.29*	3.59	16.97**	4.19*	1.90
(MEQ/L)	MG	5.59*	3.45	16.45**	6.74*	3.13
	NA	10.00	4.79	36.97	20.45	10.53
	K	0.18	0.12	0.24	0.26	0.13
ANIONS	HCO3	5.52	3.49	5.41	3.36	4.88
(MEQ/L)	SO4	14.57**	6.25*	37.48**	14.99**	7.20*
	CL	3.95	2.26	36.10**	10.43*	3.02
	NO3	0.03	<.016	<.032	0.03	<.032
SI (MG/L)		37.0	16.0	20.8	18.0	28.3
DOMES. CLASS		3	2	3	3	2
AGRIC. CLASS		C3S2	C3S1	C5S3	C4S3	C3S2

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** CONCENTRATION EXCEEDS W.H.O. MAXIMUM PERMISSIBLE LEVEL

MUQDISHO WATER SUPPLY
STAGE IIA DATA
CHEMISTRY SUMMARY

GRID REF		56862585	57102539
WELL NUMBER		EO 6	87
SAMPLE		30225	30150
DATE		28 APR 83	8 OCT 82
BASIN		1	1
AQUIFER		2	2
SOURCE		4	2
DEPTH			
TOTAL SOLIDS			
ELEC. COND.		1410.	4570.
PH		8.50	7.70
CATIONS	CA	48.	122.
(MG/L)	MG	35.	108.
	NA	210.	800.
	K	6.	10.
ANIONS	HCO3	343.	649.
(MG/L)	SO4	220.	1150.
	CL	80.	575.
	NO3	<2.0	<1.0
CATIONS	CA	2.40	6.09*
(MEQ/L)	MG	2.88	8.88*
	NA	9.13	34.80
	K	0.15	0.25
ANIONS	HCO3	5.62	10.64
(MEQ/L)	SO4	4.58*	23.94**
	CL	2.26	16.22*
	NO3	<.032	<.016
SI (MG/L)		25.0	44.0
DOMES. CLASS		2	3
AGRIC. CLASS		C3S2	C4S4

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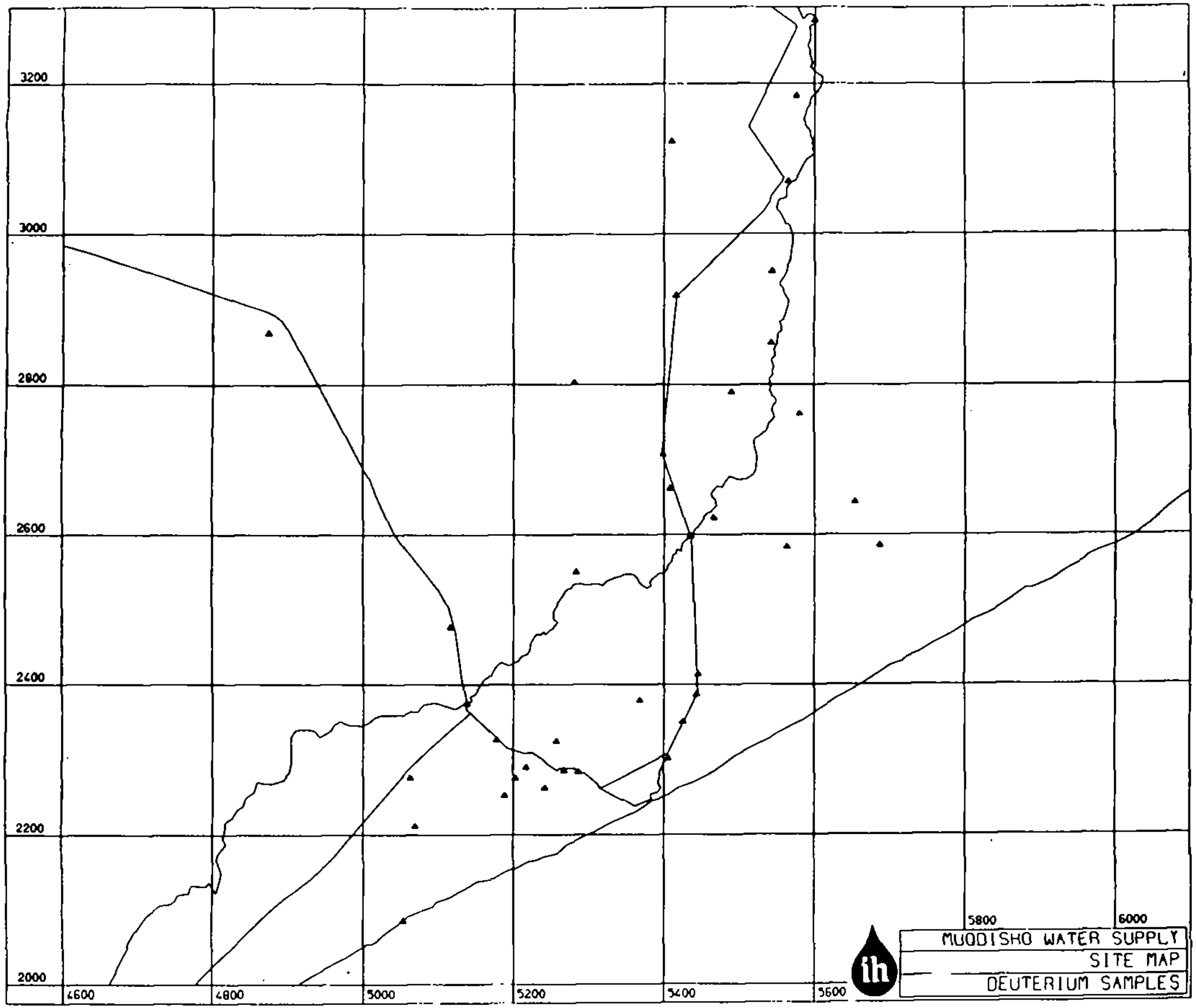


3200
3000
2800
2600
2400
2200
2000
4600
4800
5000
5200
5400
5600
5800
6000
MUQDISHO WATER SUPPLY
SITE MAP
DEUTERIUM SAMPLES

Figure C.2

MUQDISHO WATER SUPPLY
STABLE ISOTOPE DATA

SAMPLE	GRID REF	WELL	DATE	O-18	H-2	
S168	43742868	93	01 OCT 82	-2.1	-9.	
S166	50532086	88	01 OCT 82	-1.4	-7.	
S167	50622275	57	01 OCT 82	-0.1	+5.	
S197	50692211	E014	29 JUL 83	-0.3	+4.	
S158	50762601	6	01 OCT 82	-1.0	-2.	
S157	51162476	5	01 OCT 82	-0.4	+2.	
S203	51382375	RIVER	31 AUG 83	-1.2	+1.	AFGOOYE
S198	51882252	OW4	06 JUL 83	-1.0	+4.	
S177	52022275	PW32	29 MAR 83	-0.2	0.	
S202	52072279	PW29	20 JUL 83	-1.3	-3.	
S201	52092231	PW27	08 JUL 83	-0.3	+2.	
S199	52172239	OW5	26 JUN 83	-0.4	+4.	
S175	52272295	PW16	11 MAY 83	+0.1	+5.	
S174	52272297	PW15	20 APP 83	-0.2	+4.	
S176	52292299	PW14	12 APR 83	-0.1	+5.	
S200	52412262	OW6	13 AUG 83	-0.7	+2.	
S207	52572323	PW11	15 SEP 83	-0.5	+2.	
S206	52802802	E09TW	12 SEP 83	-2.0	-8.	
S196	52832549	E010	24 AUG 83	-1.5	-5.	
S160	53922703	48	01 OCT 82	+0.3	+5.	
S159	54082661	55	01 OCT 82	-0.2	+4.	
S165	54103124	12	01 OCT 82	-2.0	-7.	
S118	54162918	E013	22 MAR 83	-2.6	-11.	
S204	54352598	RIVER	31 AUG 83	-1.2	+1.	BALCAD
S163	54692622	19	01 OCT 82	-0.1	+4.	
S173	54902790	E08	03 APP 83	-0.5	-1.	
S205	55092515	E011	13 OCT 83	-0.5	+3.	
S117	55422950	E07A	25 FEB 83	-0.2	+4.	
S195	55422950	E07A	21 AUG 83	-0.4	+4.	
S116	55432950	E07	25 FEB 83	-2.3	-9.	
S194	55432950	E07	16 AUG 83	-2.2	-11.	
S170	55432855	94	01 OCT 82	-0.8	0.	
S169	55502454	90	01 OCT 82	-0.6	+2.	
S179	55632583	E04	07 JUN 83	-0.6	-2.	
S161	55643070	34	01 OCT 82	-0.2	+5.	
S164	55753134	85	01 OCT 82	-0.4	0.	
S178	55812761	E03	31 MAY 83	-0.3	+2.	
S162	55993283	93	01 OCT 82	-0.7	+1.	
S172	56542643	E05	19 APR 83	-0.2	0.	
S171	56862585	E06	28 APR 83	-0.3	+2.	

D. GROUNDWATER CONDUCTIVITY AND TEMPERATURE

APPENDIX D CONDUCTIVITY AND TEMPERATURE

Determinations of electrical conductivity and temperature were taken when a chemistry sample was collected. In addition point readings were taken at suitable boreholes and wells during the 1982 reconnaissance survey. The locations for the conductivity and temperature measurements are shown in Figures D.1 and D.2 respectively.

Conductivity and temperature profiles were taken using borehole logging techniques at exploratory boreholes and other selected boreholes. The point reading of conductivity have been corrected to 25°C while the profile conductivity are for the corresponding temperature on the temperature log.

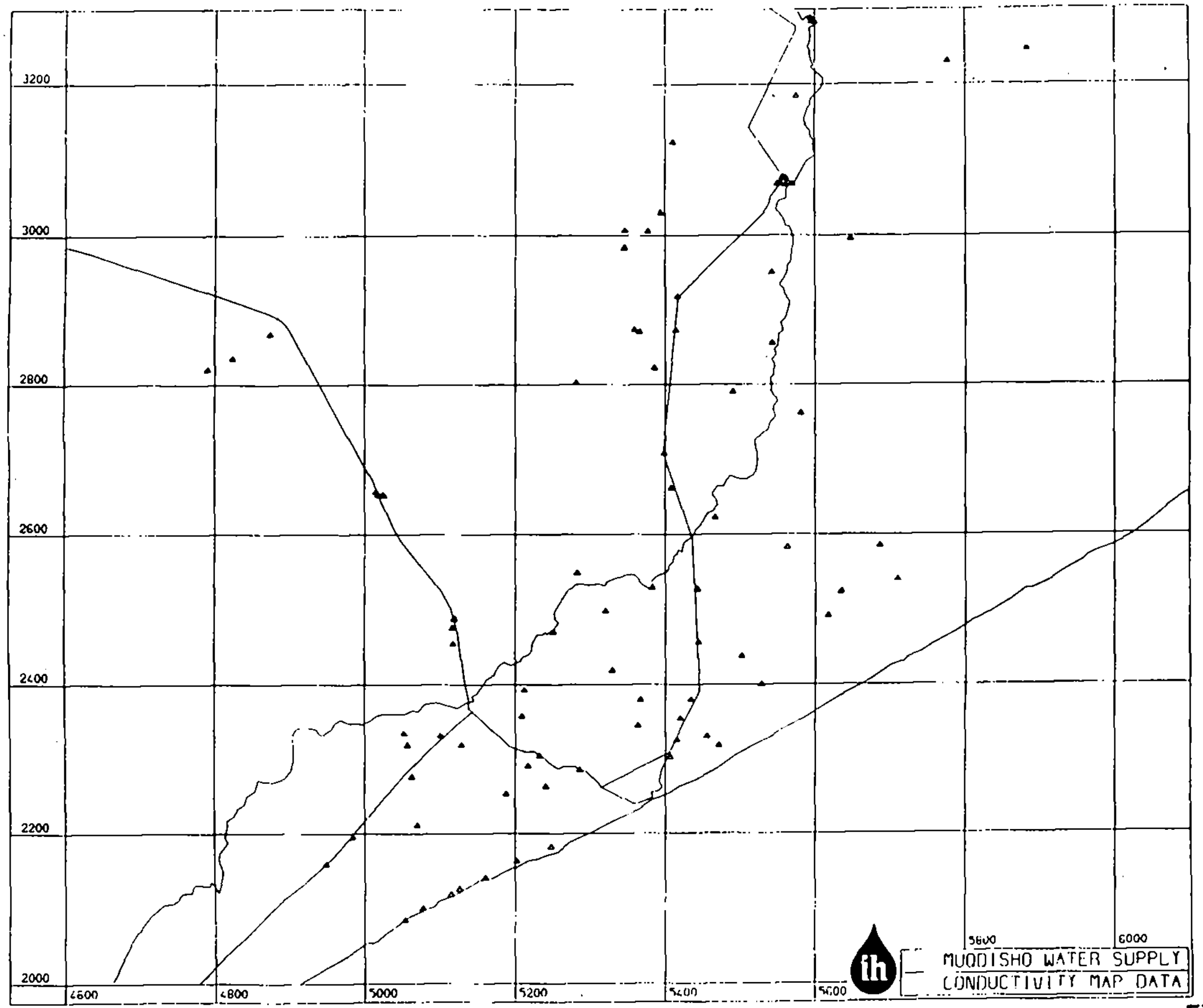

3200
3000
2800
2600
2400
2200
2000
4600
4800
5000
5200
5400
5600
5800
6000
MUODISHO WATER SUPPLY
CONDUCTIVITY MAP DATA

Figure D.1

MUQDISHU WATER SUPPLY
CONDUCTIVITY LISTING
ALL THE DATA

GRID REF	SITE NO	DATE	CONDUCTIVITY (MICROMHOS/CM)
47902820	97	1 OCT 82	18300.0
48242835	96	1 OCT 82	26000.0
48742868	98	1 OCT 82	4980.0
48752689	95	1 OCT 82	5100.0
49312061	102	1 OCT 82	1200.0
49492159	60	1 OCT 82	4030.0
49842195	58	1 OCT 82	6820.0
50152656	101	1 OCT 82	4850.0
50182652	99	1 OCT 82	2100.0
50242652	69	1 OCT 82	4200.0
50262651	100	1 OCT 82	6600.0
50522332	114	1 OCT 82	2470.0
50532086	88	1 OCT 82	6340.0
50562316	116	1 OCT 82	2500.0
50622275	57	1 OCT 82	3720.0
50692211	EO 14	29 JUL 83	2010.0
50762101	107	1 OCT 82	6540.0
50762661	6	1 OCT 82	6810.0
51002329	56	1 OCT 82	1360.0
51142119	106	1 OCT 82	9440.0
51162476	5	1 OCT 82	2040.0

MUQDISHU WATER SUPPLY
CONDUCTIVITY LISTING
ALL THE DATA

GRID REF	SITE NO	DATE	CONDUCTIVITY (MICROMHOS/CM)
51172454	79	1 OCT 82	2130.0
51182488	3	1 OCT 82	2010.0
51192488	4	1 OCT 82	1300.0
51252126	108	1 OCT 82	6880.0
51282316	64	1 OCT 82	1087.0
51602141	105	1 OCT 82	1290.0
51882252	OW 4	6 JUL 83	3050.0
52022163	104	1 OCT 82	6360.0
52172289	OW 5	26 JUN 83	1850.0
52412262	OW 6	13 AUG 83	1750.0
52482182	103	1 OCT 82	3540.0
52812802	EO 9	8 MAR 83	2850.0
52832549	EO 10	24 AUG 83	3480.0
53162675	74	1 OCT 82	2600.0
53262672	73	1 OCT 82	1900.0
53452983	67	1 OCT 82	3000.0
53462984	89	1 OCT 82	1860.0
53463007	68	1 OCT 82	2610.0
53592873	77	1 OCT 82	2480.0
53662870	76	1 OCT 82	4500.0
53773006	66	1 OCT 82	3010.0

MUQDISHU WATER SUPPLY
CONDUCTIVITY LISTING
ALL THE DATA

GRID REF	SITE NO	DATE	CONDUCTIVITY (MICROMHOS/CM)
53852822	72	1 OCT 82	2850.0
53943030	65	1 OCT 82	3600.0
53982708	48	1 OCT 82	3100.0
54082661	55	1 OCT 82	1370.0
54103124	12	1 OCT 82	5000.0
54142872	71	1 OCT 82	2700.0
54162918	ED 13	22 MAR 83	2050.0
54422527	10	1 OCT 82	960.0
54662622	19	1 OCT 82	1144.0
54902790	ED 8	3 APR 83	3220.0
55282400	86	1 OCT 82	4930.0
55422950	ED 7A	21 AUG 83	5250.0
55432855	94	1 OCT 82	2130.0
55432950	ED 7	16 AUG 83	6820.0
55502454	90	1 OCT 82	2550.0
55503068	38	1 OCT 82	5800.0
55543068	40	1 OCT 82	1450.0
55573077	37	1 OCT 82	4000.0
55583076	32	1 OCT 82	2200.0
55613067	35	1 OCT 82	1430.0
55613076	36	1 OCT 82	1660.0

MUQDISHU WATER SUPPLY
CONDUCTIVITY LISTING
ALL THE DATA

GRID REF	SITE NO	DATE	CONDUCTIVITY (MICROMHOS/CM)
55632583	ED 4	7 JUN 83	1110.0
55643070	34	1 OCT 82	3670.0
55703068	33	1 OCT 82	2100.0
55753184	85	1 OCT 82	1833.0
55812761	ED 3	31 MAY 83	2120.0
55943288	61	1 OCT 82	1700.0
55953283	82	1 OCT 82	1750.0
55993283	83	1 OCT 82	1154.0
56172492	92	1 OCT 82	5620.0
56342524	93	1 OCT 82	3090.0
56472995	ED 1	10 FEB 83	6600.0
56662893	41	1 OCT 82	2000.0
56742750	ED 2	10 OCT 83	1400.0
56862585	ED 6	24 APR 83	1340.0
57102539	87	1 OCT 82	4550.0
57123146	62	1 OCT 82	4000.0
57763230	63	1 OCT 82	5300.0
58802681	2	1 OCT 82	6770.0
58833246	117	1 OCT 82	5300.0

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 50282630
SITE NAME EO 12
28 NOV 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
150.00	5350.0	157.00	5350.0
152.00	5350.0	158.00	5350.0
153.00	5350.0	159.00	5350.0
154.00	5400.0	160.00	5250.0
155.00	5400.0	161.10	5200.0
156.00	5350.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 50692211
SITE NAME ED 14
23 NOV 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
175.00	2200.0	189.00	2375.0
180.00	2200.0	190.00	2425.0
182.00	2350.0	191.00	2425.0
183.00	2425.0	192.00	2425.0
185.00	2425.0	193.00	2425.0
186.00	2400.0	194.00	2425.0
187.00	2425.0	195.00	2400.0
188.00	2425.0	196.00	2400.0

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 51882252
SITE NAME OW 4
29 AUG 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
235.00	3400.0	245.00	3475.0
236.00	3400.0	246.00	3500.0
237.00	3400.0	247.00	3500.0
238.00	3400.0	248.00	3520.0
239.00	3400.0	249.00	3520.0
240.00	3450.0	250.00	3520.0
241.00	3450.0	251.00	3520.0
242.00	3475.0	252.00	3350.0
243.00	3475.0	253.00	3050.0
244.00	3475.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 52172289
SITE NAME DW 5
29 AUG 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
236.00	2160.0	244.00	2050.0
237.00	2175.0	245.00	2050.0
238.00	2080.0	246.00	2080.0
239.00	2050.0	247.00	2080.0
240.00	2080.0	248.00	2080.0
241.00	2050.0	249.00	2080.0
242.00	2080.0	250.00	2080.0
243.00	2080.0	251.00	2450.0

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 52412262
SITE NAME OW 6
9 OCT 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
244.00	2250.0	256.00	2350.0
246.00	2250.0	257.00	2350.0
247.00	2250.0	258.00	2350.0
248.00	2250.0	259.00	2350.0
249.00	2250.0	260.00	2340.0
250.00	2300.0	261.00	2750.0
251.00	2350.0	262.00	3300.0
252.00	2350.0	263.00	3400.0
253.00	2350.0	264.00	3400.0
254.00	2400.0	265.00	3400.0
255.00	2400.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 52812802
SITE NAME EO 9
30 AUG 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
144.00	3040.0	155.00	3060.0
145.00	3040.0	156.00	3060.0
146.00	3050.0	157.00	3060.0
147.00	3050.0	158.00	3060.0
148.00	3050.0	159.00	3060.0
149.00	3050.0	160.00	3100.0
150.00	3050.0	161.00	3100.0
151.00	3050.0	162.00	3150.0
152.00	3060.0	163.00	3330.0
153.00	3060.0	164.00	3330.0
154.00	3060.0	165.00	3350.0

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 52832549
SITE NAME EO 10
10 OCT 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
178.00	3450.0	191.00	3340.0
180.00	3400.0	192.00	3340.0
182.00	3400.0	193.00	3700.0
183.00	3400.0	194.00	3720.0
184.00	3350.0	195.00	3720.0
185.00	3350.0	196.00	3720.0
186.00	3350.0	197.00	3720.0
187.00	3350.0	198.00	3720.0
188.00	3350.0	199.00	3710.0
189.00	3340.0	200.00	3720.0
190.00	3340.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 54152322
SITE NAME MGQ3CP
6 DEC 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
65.00	1000.0	115.00	3000.0
70.00	1000.0	120.00	3000.0
75.00	2750.0	125.00	3000.0
80.00	2950.0	130.00	3000.0
85.00	2950.0	135.00	3050.0
90.00	2950.0	140.00	3050.0
95.00	2950.0	145.00	3050.0
100.00	2950.0	150.00	3050.0
105.00	3000.0	155.00	3050.0
110.00	3000.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 54162918
SITE NAME EO 13
9 AUG 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
150.00	2275.0	159.00	2300.0
151.00	2275.0	160.00	2300.0
152.00	2275.0	161.00	2275.0
153.00	2275.0	162.00	2275.0
154.00	2275.0	163.00	2300.0
155.00	2300.0	164.00	2300.0
156.00	2300.0	165.00	2300.0
157.00	2300.0	166.00	2320.0
158.00	2300.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 54552327
SITE NAME MGQ2CP
6 DEC 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
70.00	7200.0	135.00	7600.0
80.00	7600.0	140.00	7600.0
85.00	7600.0	142.00	7600.0
90.00	7600.0	144.00	7600.0
95.00	7600.0	146.00	7600.0
100.00	7600.0	148.00	8250.0
105.00	7600.0	150.00	8800.0
110.00	7600.0	152.00	8800.0
115.00	7600.0	154.00	8800.0
120.00	7600.0	156.00	8800.0
125.00	7600.0	158.00	8800.0
130.00	7600.0	160.00	8800.0

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 54902790
SITE NAME ED 8
27 AUG 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
155.00	2460.0	165.00	2400.0
156.00	2460.0	166.00	2400.0
157.00	2420.0	167.00	2400.0
158.00	2400.0	168.00	2400.0
159.00	2380.0	169.00	2920.0
160.00	2380.0	170.00	3200.0
161.00	2400.0	171.00	3300.0
162.00	2400.0	172.00	3350.0
163.00	2380.0	173.00	3350.0
164.00	2400.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 55092515
SITE NAME EO 11
10 OCT 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
220.00	2100.0	231.00	2500.0
221.00	2100.0	232.00	2600.0
222.00	2075.0	233.00	2600.0
223.00	2080.0	234.00	2650.0
224.00	2080.0	235.00	2700.0
225.00	2080.0	236.00	2700.0
226.00	2100.0	237.00	2700.0
227.00	2150.0	238.00	2750.0
228.00	2200.0	239.00	2730.0
229.00	2275.0	240.00	2750.0
230.00	2350.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 55422950
SITE NAME EO 7A
31 JUL 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
23.50	5250.0	26.00	5100.0
24.00	5250.0	26.50	5050.0
24.50	5170.0	27.00	5050.0
25.00	5150.0	27.50	5050.0
25.50	5125.0	28.00	5050.0

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 55432950
SITE NAME EO 7
31 JUL 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
160.00	5900.0	167.00	5800.0
161.00	5800.0	168.00	5800.0
162.00	5800.0	169.00	5800.0
163.00	5800.0	170.00	5800.0
164.00	5750.0	171.00	5800.0
165.00	5800.0	172.00	4875.0
166.00	5800.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 55632583
SITE NAME ED 4
1 SEP 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
200.00	1300.0	211.00	1250.0
201.00	1300.0	212.00	1250.0
202.00	1300.0	213.00	1250.0
203.00	1300.0	214.00	1250.0
204.00	1300.0	215.00	1275.0
205.00	1300.0	216.00	1400.0
206.00	1300.0	217.00	1850.0
207.00	1250.0	218.00	2700.0
208.00	1275.0	219.00	2700.0
209.00	1250.0	220.00	2700.0
210.00	1275.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 55812761
SITE NAME EO 3
27 NOV 83

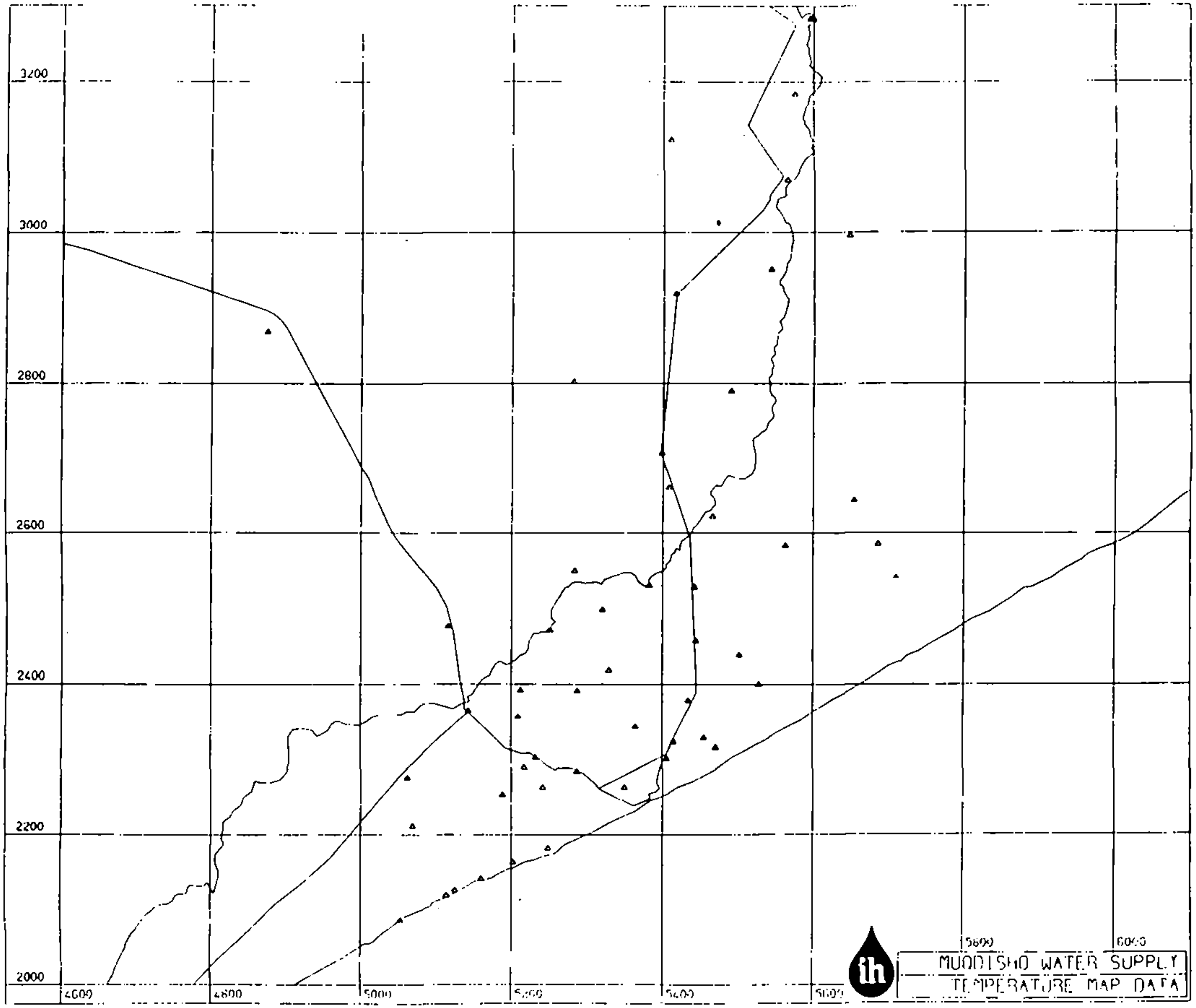
DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
120.00	1350.0	132.00	1225.0
125.00	1250.0	133.00	1200.0
126.00	1250.0	134.50	1200.0
127.00	1250.0	136.00	1200.0
128.00	1225.0	137.00	1200.0
129.00	1225.0	138.00	1200.0
130.00	1225.0	140.00	1200.0
131.00	1250.0	145.00	1200.0

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 56472995
SITE NAME EO 1
9 AUG 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
130.00	7100.0	145.00	8000.0
132.00	7100.0	146.00	7800.0
133.00	7100.0	147.00	7800.0
134.00	7100.0	148.00	7800.0
135.00	7100.0	149.00	7800.0
136.00	7100.0	150.00	8000.0
137.00	7100.0	151.00	7800.0
138.00	7300.0	152.00	7800.0
139.00	7700.0	153.00	7800.0
140.00	7800.0	154.00	8000.0
141.00	7800.0	155.00	8000.0
142.00	7800.0	156.00	8000.0
143.00	7800.0	157.00	8000.0
144.00	7800.0		

MUQDISHU WATER SUPPLY
CONDUCTIVITY LOG
ALL THE DATA
GRID REF. 56542643
SITE NAME ED 5
1 SEP 83

DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)	DEPTH (METRES)	CONDUCTIVITY (MICRO-MHOS)
244.00	3825.0	254.00	3860.0
245.00	3800.0	255.00	3860.0
246.00	3800.0	256.00	3850.0
247.00	3800.0	257.00	3850.0
248.00	3800.0	258.00	3850.0
249.00	3800.0	259.00	3850.0
250.00	3800.0	260.00	3850.0
251.00	3860.0	261.00	3850.0
252.00	3860.0	262.00	3800.0
253.00	3860.0		



3200
3000
2800
2600
2400
2200
2000
4600
4800
5000
5200
5400
5600
5800
6000
MUQDISHO WATER SUPPLY
TEMPERATURE MAP DATA

Figure D.2

MUQDISHU WATER SUPPLY
TEMPERATURE LISTING
ALL THE DATA

GRID REF	SITE NO	DATE	TEMPERATURE (DEGREES C)
48742868	98	1 OCT 82	32.8
50532086	88	1 OCT 82	29.8
50622275	57	1 OCT 82	32.5
50692211	EO 14	29 JUL 83	29.9
50762661	6	1 OCT 82	33.6
51142119	106	1 OCT 82	29.7
51162476	5	1 OCT 82	32.1
51252126	108	1 OCT 82	30.1
51602141	105	1 OCT 82	29.3
51882252	OW 4	6 JUL 83	31.6
52022163	104	1 OCT 82	29.3
52172289	OW 5	26 JUN 83	29.3
52412262	OW 6	13 AUG 83	26.0
52482182	103	1 OCT 82	29.1
52812802	EO 9	8 MAR 83	35.0
52832549	EO 10	24 AUG 83	27.6
53982708	48	1 OCT 82	33.8
54082661	55	1 OCT 82	33.7
54103124	12	1 OCT 82	36.6
54162918	EO 13	22 MAR 83	34.4
54422527	10	1 OCT 82	30.2

MUQDISHU WATER SUPPLY
TEMPERATURE LISTING
ALL THE DATA

GRID REF	SITE NO	DATE	TEMPERATURE (DEGREES C)
54662622	19	1 OCT 82	28.5
54902790	EO 8	3 APR 83	34.0
55282400	86	1 OCT 82	31.8
55422950	EO 7A	21 AUG 83	28.3
55432950	EO 7	16 AUG 83	31.9
55502454	90	1 OCT 82	36.9
55632583	EO 4	7 JUN 83	31.7
55643070	34	1 OCT 82	28.5
55753184	85	1 OCT 82	32.5
55953283	82	1 OCT 82	28.4
55993283	83	1 OCT 82	30.4
56472995	EO 1	10 FEB 83	34.0
56542643	EO 5	19 APR 83	31.8
56862585	EO 6	24 APR 83	36.8
57102539	87	1 OCT 82	31.0
58802681	2	1 OCT 82	32.1

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 50282630
SITE NAME EO 12
28 NOV 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
150.00	37.0	157.00	37.0
152.00	37.0	158.00	37.0
153.00	37.0	159.00	37.0
154.00	37.0	160.00	36.8
155.00	37.0	161.10	36.8
156.00	37.0		

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 50692211
SITE NAME EO 14
23 NOV 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
175.00	32.8	189.00	33.2
180.00	32.9	190.00	33.2
182.00	33.0	191.00	33.2
183.00	33.0	192.00	33.2
185.00	33.0	193.00	33.2
186.00	33.2	194.00	33.2
187.00	33.2	195.00	33.2
188.00	33.2	196.00	33.2

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 51882252
SITE NAME OW 4
29 AUG 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
235.00	38.0	245.00	38.5
236.00	38.5	246.00	38.5
237.00	38.5	247.00	38.5
238.00	38.5	248.00	39.0
239.00	38.5	249.00	39.0
240.00	38.5	250.00	39.0
241.00	38.5	251.00	39.0
242.00	38.5	252.00	39.0
243.00	38.5	253.00	39.0
244.00	38.5		

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 52172289
SITE NAME OW 5
29 AUG 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
236.00	35.0	244.00	35.5
237.00	35.0	245.00	35.5
238.00	35.0	246.00	35.5
239.00	35.5	247.00	35.5
240.00	35.5	248.00	35.5
241.00	35.5	249.00	36.0
242.00	35.5	250.00	36.0
243.00	35.5	251.00	36.0

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 52412262
SITE NAME OW 6
9 OCT 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
244.00	36.5	256.00	37.0
246.00	36.5	257.00	37.0
247.00	36.8	258.00	37.0
248.00	36.8	259.00	37.0
249.00	36.8	260.00	37.0
250.00	36.8	261.00	37.0
251.00	36.8	262.00	37.0
252.00	36.8	263.00	37.0
253.00	37.0	264.00	37.1
254.00	37.0	265.00	37.1
255.00	37.0		

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 52812802
SITE NAME EO 9
30 AUG 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
144.00	36.0	155.00	37.0
145.00	36.0	156.00	37.0
146.00	36.0	157.00	37.0
147.00	36.5	158.00	37.0
148.00	36.5	159.00	37.0
149.00	36.5	160.00	37.0
150.00	36.5	161.00	37.0
151.00	36.5	162.00	37.0
152.00	36.5	163.00	37.0
153.00	36.5	164.00	37.0
154.00	36.5	165.00	37.0

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 52832549
SITE NAME EO 10
10 OCT 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
178.00	34.5	191.00	34.8
180.00	34.5	192.00	35.0
182.00	34.7	193.00	35.0
183.00	34.7	194.00	35.0
184.00	34.7	195.00	35.0
185.00	34.7	196.00	35.0
186.00	34.7	197.00	35.0
187.00	34.7	198.00	35.0
188.00	34.7	199.00	35.0
189.00	34.8	200.00	35.0
190.00	34.8		

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 54152322
SITE NAME MGQ3CP
6 DEC 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
65.00	29.0	115.00	30.2
70.00	29.5	120.00	30.2
75.00	29.9	125.00	30.2
80.00	30.2	130.00	31.5
85.00	30.2	135.00	31.5
90.00	30.2	140.00	31.5
95.00	29.9	145.00	31.5
100.00	29.9	150.00	31.5
105.00	29.9	155.00	31.5
110.00	30.2		

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 54162918
SITE NAME EO 13
9 AUG 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
150.00	36.5	159.00	36.5
151.00	36.5	160.00	36.5
152.00	36.5	161.00	36.5
153.00	36.5	162.00	37.0
154.00	36.5	163.00	37.0
155.00	36.5	164.00	37.0
156.00	36.5	165.00	37.0
157.00	36.5	166.00	37.0
158.00	36.5		

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 54552327
SITE NAME MGQ2CP
6 DEC 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
70.00	33.5	135.00	35.5
80.00	35.0	140.00	35.5
85.00	35.5	142.00	35.5
90.00	35.5	144.00	35.0
95.00	35.5	146.00	35.0
100.00	35.5	148.00	35.0
105.00	35.5	150.00	35.0
110.00	35.5	152.00	35.0
115.00	35.5	154.00	35.0
120.00	35.5	156.00	34.5
125.00	35.5	158.00	34.5
130.00	35.5	160.00	34.5

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 54902790
SITE NAME EO 8
27 AUG 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)
155.00	34.5
156.00	34.5
157.00	34.5
158.00	35.0
159.00	35.0
160.00	35.0
161.00	35.5
162.00	35.5
163.00	35.5
164.00	35.5

DEPTH (METRES)	TEMPERATURE (DEGREES C)
165.00	35.5
166.00	35.5
167.00	35.5
168.00	35.5
169.00	35.5
170.00	35.5
171.00	35.5
172.00	35.5
173.00	36.0

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 55092515
SITE NAME EO 11
10 OCT 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
220.00	38.0	231.00	38.9
221.00	38.0	232.00	38.9
222.00	38.0	233.00	38.9
223.00	38.0	234.00	38.9
224.00	38.5	235.00	38.9
225.00	38.5	236.00	38.9
226.00	38.5	237.00	38.9
227.00	38.5	238.00	39.0
228.00	38.7	239.00	39.0
229.00	38.8	240.00	39.0
230.00	38.8		

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 55422950
SITE NAME EO 7A
31 JUL 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
23.50	31.0	26.00	31.0
24.00	31.0	26.50	31.0
24.50	31.0	27.00	31.5
25.00	31.0	27.50	31.5
25.50	31.0	28.00	31.5

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 55432950
SITE NAME EO 7
31 JUL 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
160.00	34.5	167.00	34.5
161.00	34.5	168.00	34.5
162.00	34.5	169.00	34.5
163.00	34.5	170.00	34.5
164.00	34.5	171.00	34.5
165.00	34.5	172.00	34.5
166.00	34.5		

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 55632583
SITE NAME ED 4
1 SEP 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
200.00	36.0	211.00	36.5
201.00	36.0	212.00	36.5
202.00	36.0	213.00	36.5
203.00	36.0	214.00	36.5
204.00	36.0	215.00	36.5
205.00	36.0	216.00	36.5
206.00	36.5	217.00	36.5
207.00	36.5	218.00	36.5
208.00	36.5	219.00	37.0
209.00	36.5	220.00	37.0
210.00	36.5		

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 55812761
SITE NAME ED 3
27 NOV 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
120.00	28.5	132.00	29.1
125.00	28.8	133.00	29.1
126.00	28.8	134.50	29.1
127.00	28.8	136.00	29.1
128.00	29.0	137.00	29.1
129.00	29.0	138.00	29.1
130.00	29.0	140.00	29.1
131.00	29.0	145.00	29.2

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 56472995
SITE NAME EO 1
9 AUG 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
130.00	35.0	145.00	35.0
132.00	35.0	146.00	35.0
133.00	35.0	147.00	35.0
134.00	35.0	148.00	35.5
135.00	35.0	149.00	35.5
136.00	35.0	150.00	35.5
137.00	35.0	151.00	35.5
138.00	35.0	152.00	35.5
139.00	35.0	153.00	35.5
140.00	35.0	154.00	35.5
141.00	35.0	155.00	35.5
142.00	35.0	156.00	35.5
143.00	35.0	157.00	35.5
144.00	35.0		

MUQDISHU WATER SUPPLY
TEMPERATURE LOG
ALL THE DATA
GRID REF. 56542643
SITE NAME ED 5
1 SEP 83

DEPTH (METRES)	TEMPERATURE (DEGREES C)	DEPTH (METRES)	TEMPERATURE (DEGREES C)
244.00	38.5	254.00	39.5
245.00	39.0	255.00	39.5
246.00	39.0	256.00	39.5
247.00	39.0	257.00	39.5
248.00	39.0	258.00	39.5
249.00	39.0	259.00	39.5
250.00	39.0	260.00	39.5
251.00	39.0	261.00	39.5
252.00	39.0	262.00	39.5
253.00	39.5		

E. EFFECT OF TIME STEP LENGTH ON PREDICTED DRAWDOWN

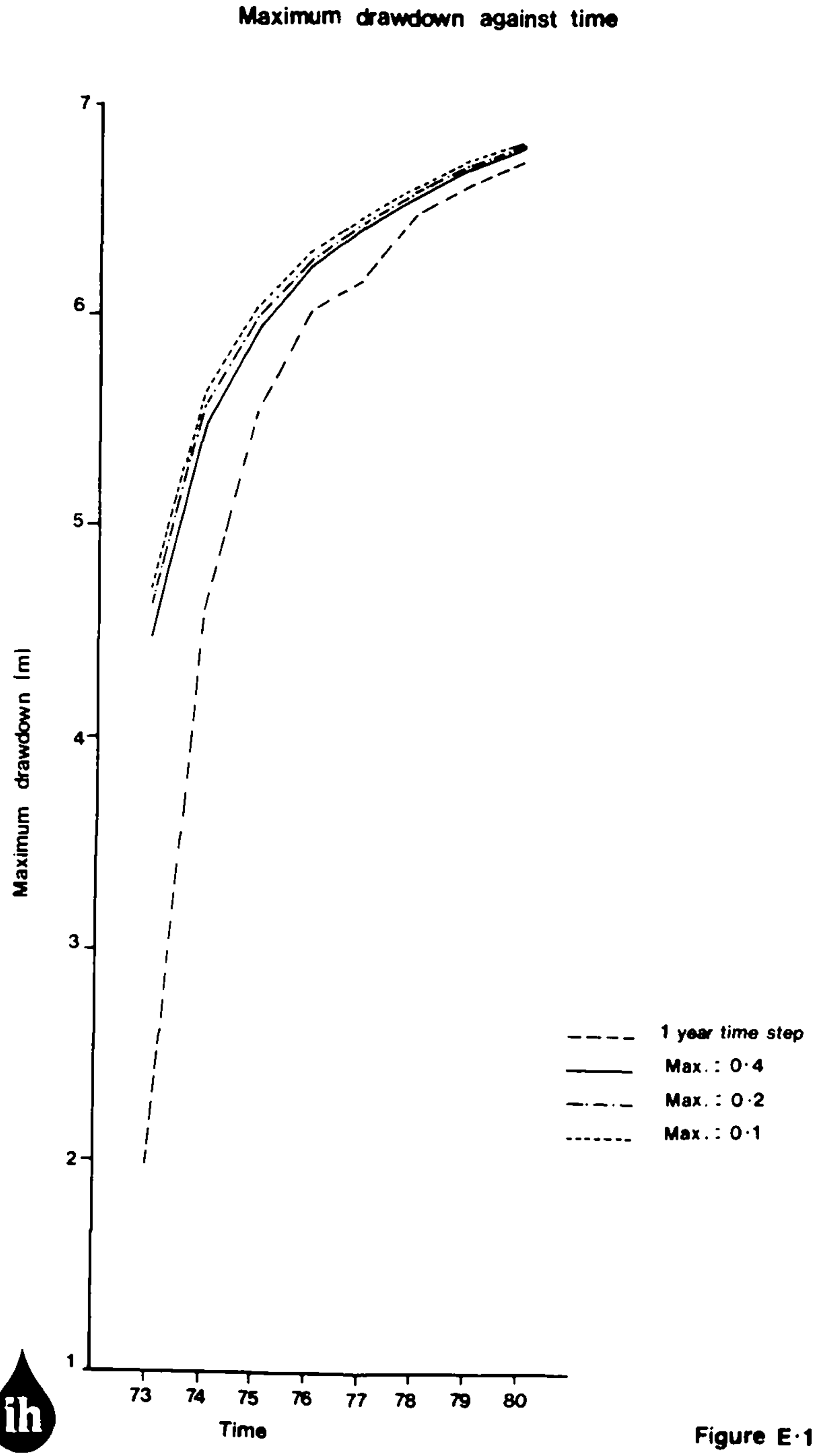
APPENDIX E

THE EFFECT OF TIME STEP LENGTH ON PREDICTED DRAWDOWN

The water management model is used to investigate the changes in storage and development of cones of depression associated with existing and proposed wellfields. It needs to predict accurately year to year changes in water table elevation in response to different abstraction regimes. Since an implicit time stepping scheme has been utilized any length of time step could in theory be used. The stability of the scheme is independent of time step length, but the longer the time step the greater the probability that the scheme will not converge to the "true" solution.

In order to investigate the effect of time step length a number of numerical experiments with variable time steps were carried out. Each of these had abstraction only from the original Balcad road wellfield. Since drawdowns are required once a year the obvious time step length is one year (365 or 366 days depending on leap years). This was used as the basic time step length which was subsequently sub-divided. Figure E.1 which shows maximum drawdown against time illustrates the results of this investigation. It is clear from this Figure that there is a logarithmic decrease with time of the amount of drawdown within a time step. Hence the one year time steps were sub-divided logarithmically. The number of sub-divisions being dependent on the ratio between the maximum drawdown in a year with a one year time step and an accuracy parameter MAX. The smaller MAX the more sub-divisions. From Figure E.1 it is clear that the drawdowns with a one year time step are significantly different from our best estimate of the true solution (the drawdowns with MAX=0.1) whereas the results with MAX equal to 0.1, 0.2 and 0.4 are almost identical. In absolute terms the drawdowns with MAX=0.4 differ by no more than 25 cm (5.3%) from the best estimate of the true solution. This error is acceptable when the quality of the model's input data is taken into consideration. The time stepping scheme with MAX=0.4 was used for all water management model experiments.

An investigation was also carried out into the effect of the time step length on the manner in which drawdown develops in the first year



Maximum drawdown against time
7
6
5
4
3
2
1
Maximum drawdown (m)
73
74
75
76
77
78
79
80
Time
1 year time step
Max.: 0·4
Max.: 0·2
Max.: 0·1

Figure E·1

after pumping started. The results of this are shown in Figure E.2. Again it is clear that the drawdowns obtained with MAX=0.4 are very good estimates of the true drawdowns.

Hence the management model formulation used in this study accurately predicts both drawdowns within a year and the drawdowns which occur from year to year.

Maximum drawdown against time within 1973

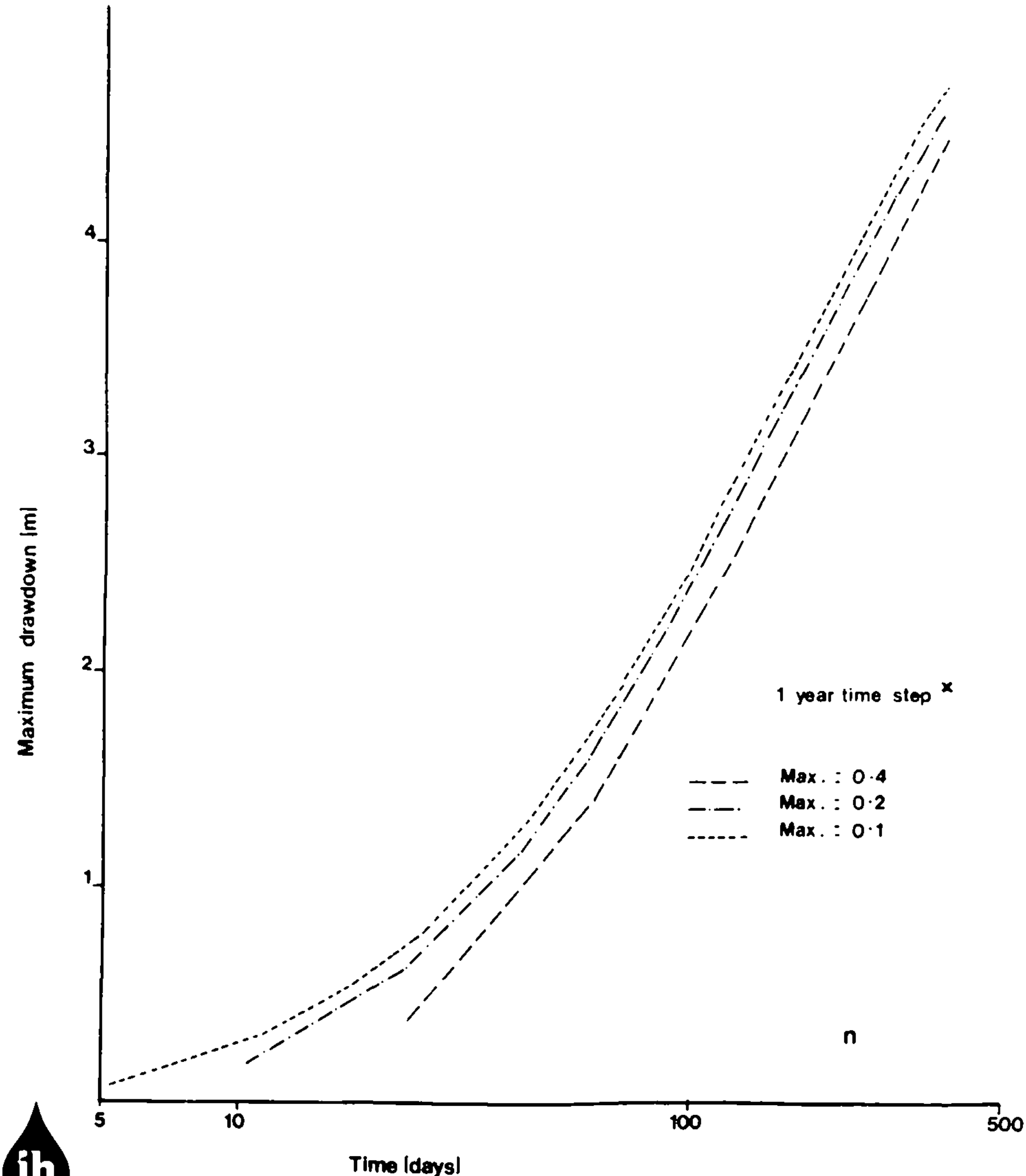


Figure E·2

F. STAGE III WELLFIELD LOCATION

APPENDIX F STAGE III WELLFIELD LOCATION

F.1 Introduction

In Section 8.6.3 of the main report (VOL II) we describe the optimum location of the Stage III wellfield in terms of the various hydrogeological constraints that exist. This location occupies four model nodes arranged in a square as shown in Figure 8.2. While this is the best hydrogeoloical location we realise that from an engineering viewpoint it offers some disadvantages and that alternative locations are more attractive. Hydrogeolgoical constraints, however, make it impossible to move the planned wellfield to a completely different location. But on the other hand it is acceptable to consider alternative nodal configurations in the same general region, where these offer engineering and economic advantages.

In this Appendix we consider two such alternative configurations and determine the hydrogeolgical penalties incurred. With this information it is possible to decide whether or not these are outweighed by the engineering and economic advantages of the alternative site.

F.2 The alternative locations

The two alternative nodal configurations tested are shown in Figure F.1. The first is a row of four nodes extending eastward from the Stage IIb wellfield while the second is a row of three nodes with a fourth positioned to the north of the most easterly node.

To compare the effects of pumping from these configurations with that of the optimum we have compiled decision matrices in the same manner as done for the optimum location in chapter 9. In this isntance though we have only undertaken model runs which simulate 35% recharge at the site of Muqdisho, since this seems most likely to represent the true situation.

Although the two alternative configurations are slightly different it was found that the drawdown response was identical for all pumping rates up to and including the 1998 rate. Only at the 1999 and 2000 rates do the responses differ slightly, because it is only at this level of abstraction that pumping begins from the fourth node which is in a different location for each configuration. Because the difference between the two alternatives are so small and marginal the results for both are presented on one set of decision matrices. (Tables F.1 to F.3).

To illustrate the drawdown response the 1998 rate has been chosen to once again enable a direct comparison to be made with those shown for the otpimum location in Chapter 9. These are presented in Figures F.2 to F.6.

F.3 The Decision Matrices: Results

The decision matrices, which are common to both alternative configurations for all pumping rats, are given in Tables F.1 to F.2. They are interpreted in exactly the same way as described in chapter 9.3 of the main report.

Comparison of Tables F.1 and 9.5 reveal the major differences between the effects of pumping at the alternative and optimum locations. Essentially pumping from the alternative locations causes constraints to be violated approximately one year earlier than for the optimum site. This results in the boundaries between the accept, provisionally accept and reject categories being moved one section higher on Table F.1.

The development of cones of depression caused by pumping from the alternative wellfields at the 1998 rate between 1990 and 2020 is presented in Figures 5.2 to F.5. Comparison with Figures 9.5 to 9.8 demonstrates the differences caused by pumping from the optimum location. Broadly the comparison shows the overall pattern and rate of drawdown to be similar for both alternative and optimum sites. The major difference is that because of their configuration the alternative sites tend to elongate the cone of depression developed in the Stage III region in an east west direction. At the same time drawdown tends to be more excessive along the eastern boundary.

By the year 2020 both the alternative and optimum sites have exceeded the northern boundary constraints at the same single point. However, because of the poorer hydrogeological situation, the amount of drawdown at this point caused by the alternative site is somewhat greater. (8.7 m as opposed to 8.1 m for the optimum site).

As a further point of comparison the 80 per cent level of acceptance for the same pumping rate are given for 2020 in Figures F.6 and 9.10. These serve once again to emphasise the poorer performance of the alternative sites, which by 2020 violate 6 northern boundary constraints in comparison to the 4 of the optimum location.

F.4 Conclusions

These model runs, using alternative model configurations for the Stage III wellfield have shown them to have poorer drawdown characteristics than the optimum location presented in the main report. Whether the drawdown penalties imposed by the alternative sites outweigh the engineering and economic advantages or vice versa is a decision that will require careful evaluation.

TABLE F.1 CONFIGURATIONS 1 and 2

Pumping with 35% Recharge at Muqdisho (Summary)

	To 2010	To 2020
1989 (24.688 M m^3/annum)		
1990 (26.824 M m^3/annum)		
1991 (28.995 M m^3/annum)		
1992 (31.342 M m^3/annum)		
1993 (33.879 M m^3/annum)		
1994 (36.621 M m^3/annum)		
1995 (39.585 M m^3/annum)		
1996 (42.643 M m^3/annum)		
1997 (45.937 M m^3/annum)		
1998 (49.486 M m^3/annum)		
1999 (53.308 M m^3/annum)		
2000 (57.426 M m^3/annum)		

Accept (80%) Provisionally Accept (60%) Reject

TABLE F.2 CONFIGURATIONS 1 and 2

Pumping with 35% Recharge at Muqdisho (Northern Boundary)

	To 2010	To 2020
1989 (24.688 M m^3/annum)		
1990 (26.824 M m^3/annum)		
1991 (28.995 M m^3/annum)		
1992 (31.342 M m^3/annum)		
1993 (33.879 M m^3/annum)		
1994 (36.621 M m^3/annum)		
1995 (39.585 M m^3/annum)		
1996 (42.643 M m^3/annum)		
1997 (45.937 M m^3/annum)		
1998 (49.486 M m^3/annum)		
1999 (53.308 M m^3/annum)		
2000 (57.426 M m^3/annum)		

Accept (80%) Provisionally Accept (60%) Reject

TABLE F.3 CONFIGURATIONS 1 and 2

Pumping with 35% Recharge at Muqdisho (Saline intrusion)

	To 2010	To 2020
1989 (24.688 M m^3/annum)		
1990 (26.824 M m^3/annum)		
1991 (28.995 M m^3/annum)		
1992 (31.342 M m^3/annum)		
1993 (33.879 M m^3/annum)		
1994 (36.621 M m^3/annum)		
1995 (39.585 M m^3/annum)		
1996 (42.643 M m^3/annum)		
1997 (45.937 M m^3/annum)		
1998 (49.486 M m^3/annum)		
1999 (53.308 M m^3/annum)		
2000 (57.426 M m^3/annum)		

Accept (80%) Provisionally Accept (60%) Reject

Alternative wellfield locations

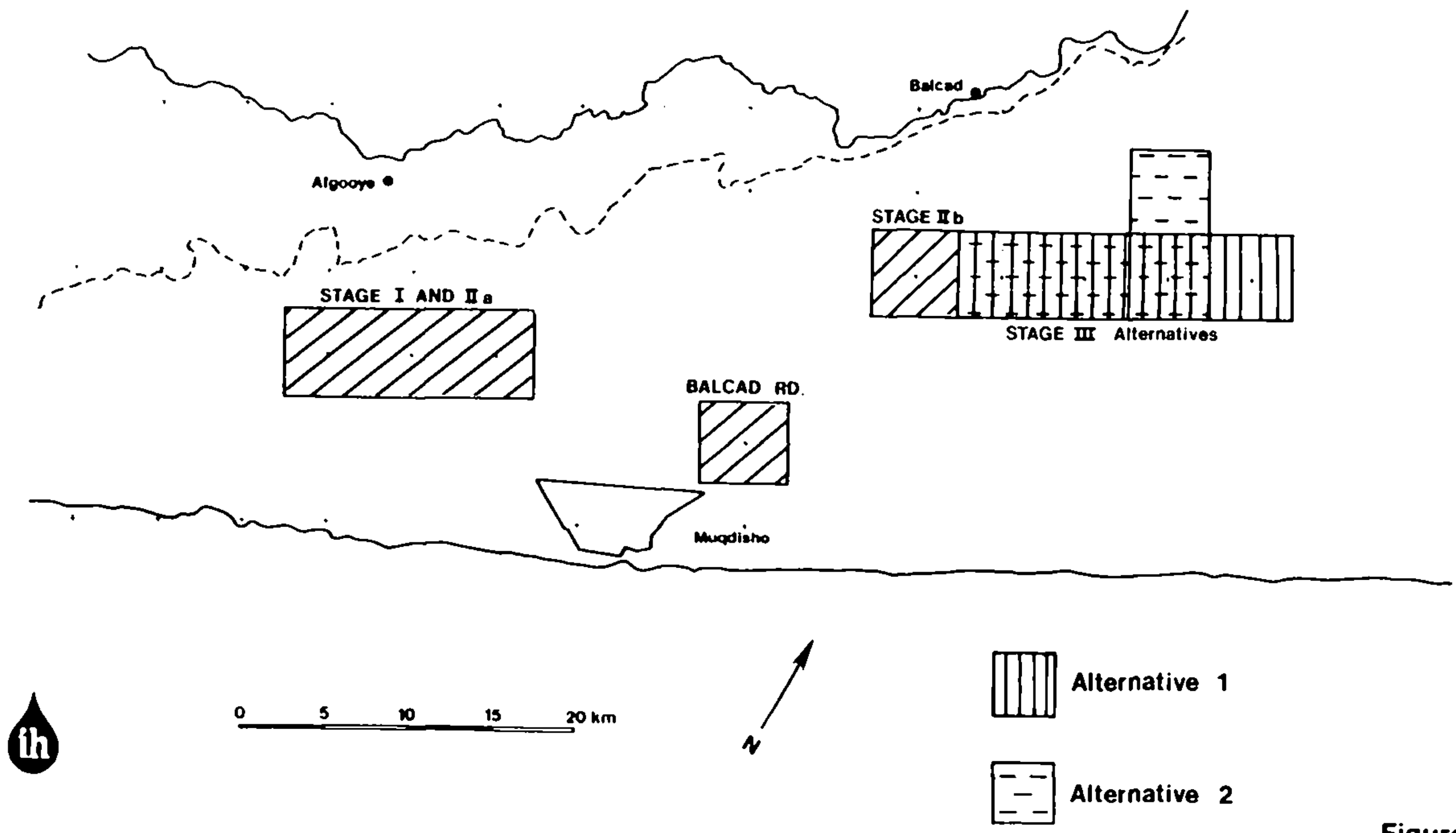


Figure F·1

Drawdown response at the 1998 rate of abstraction at the 60% level of acceptance with extra recharge
[Figures F·2 to F·5]

1990

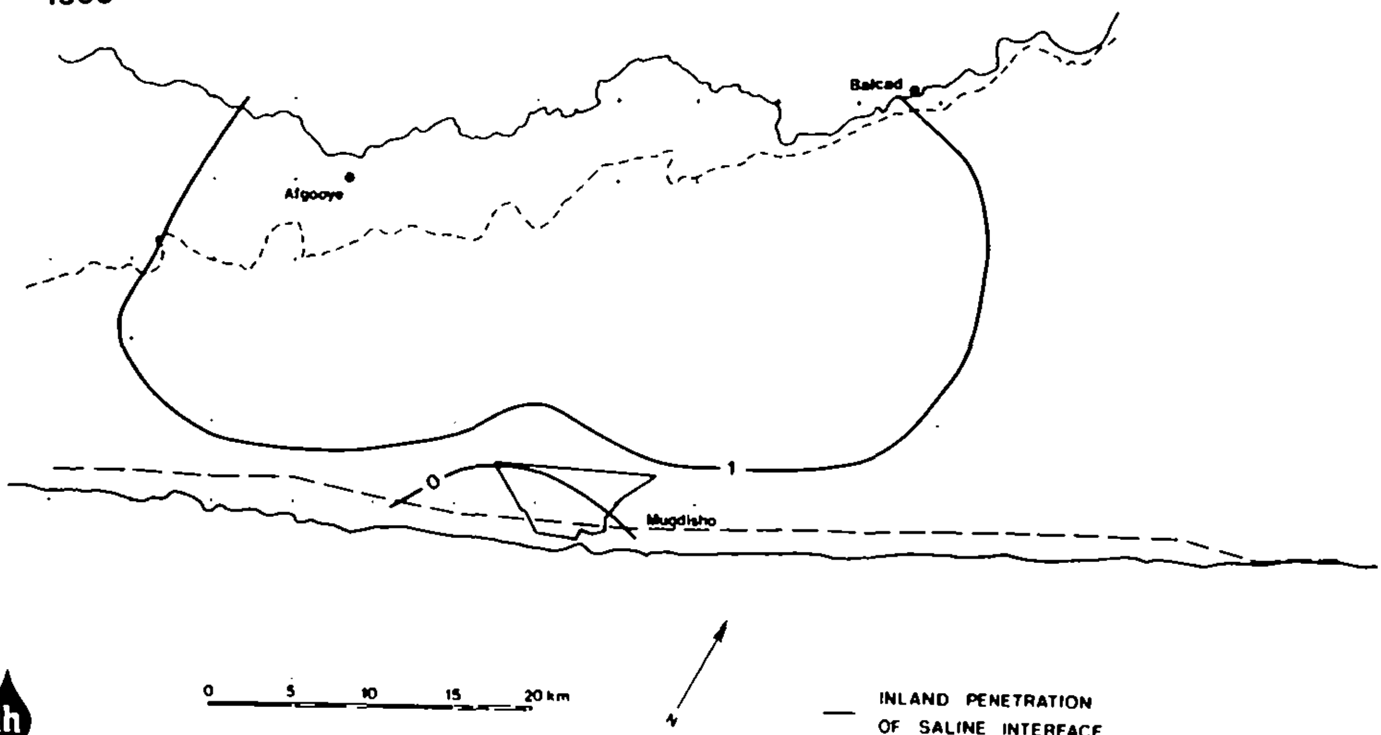


Figure F·2

1998

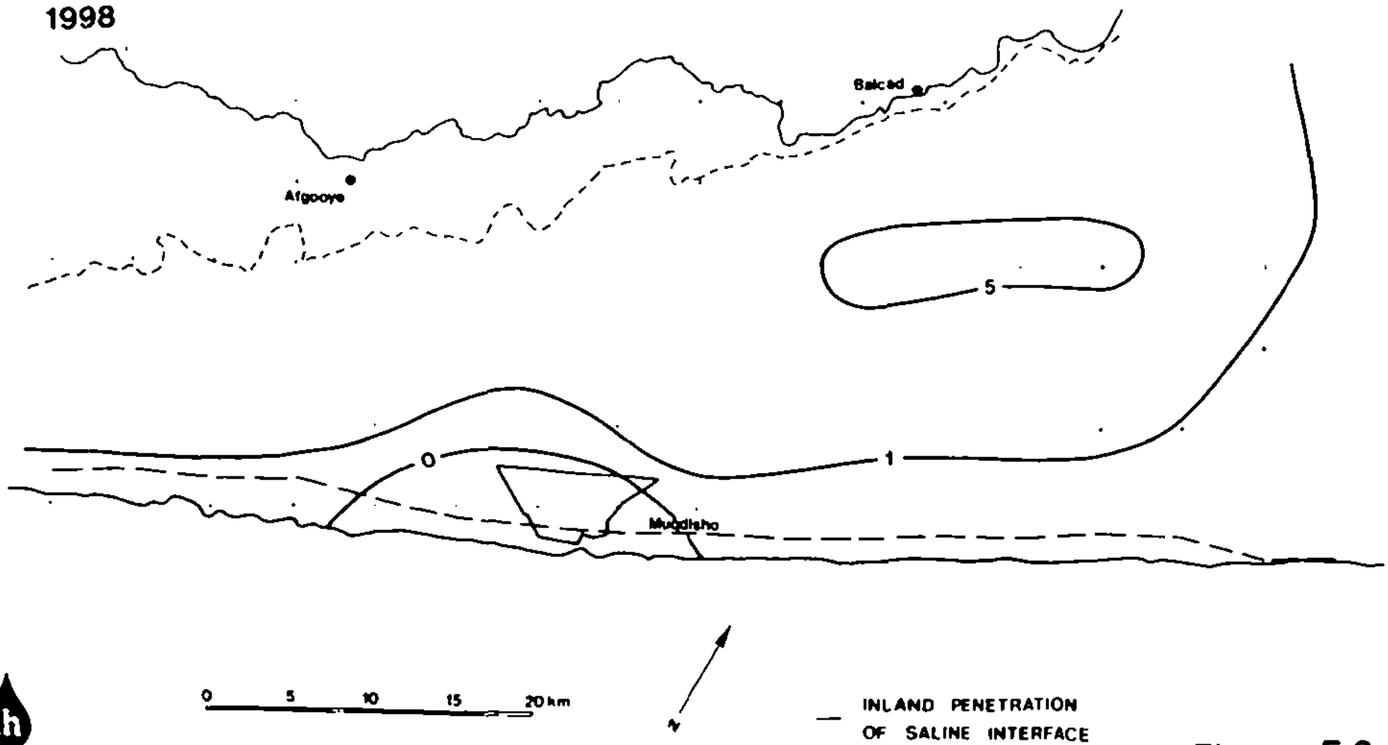


Figure F·3

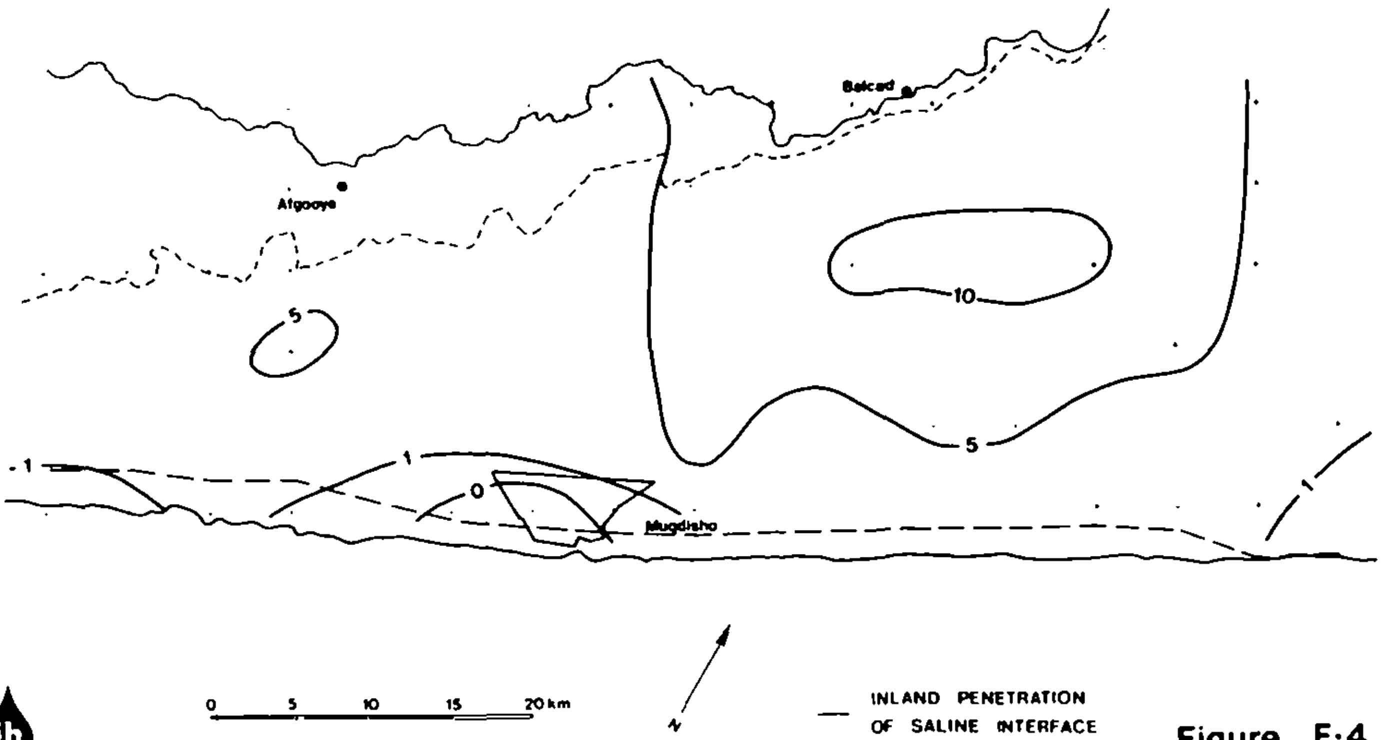


Figure F·4

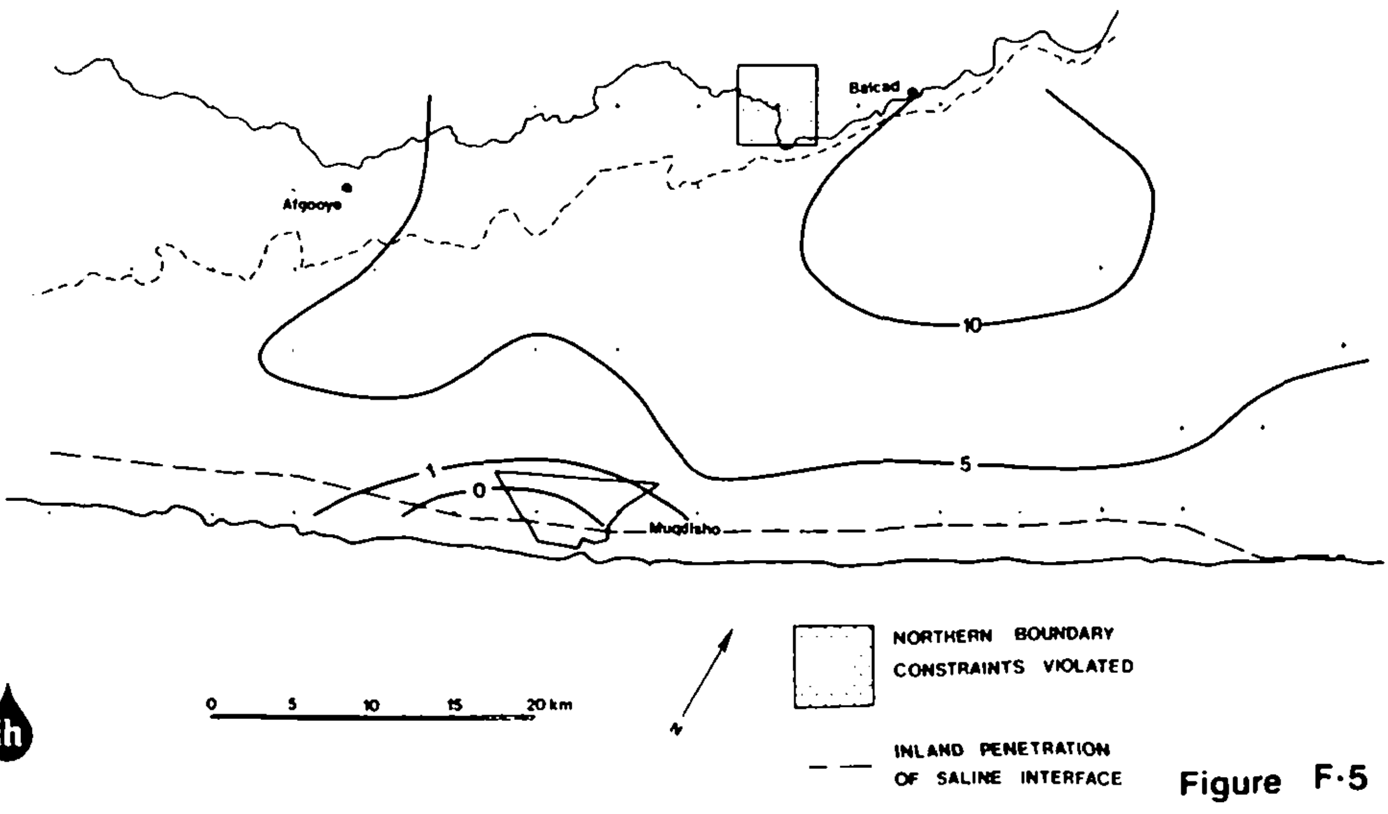


Figure F·5

Drawdown response at the 1998 rate of abstraction at the 80% level of acceptance with extra recharge

2020

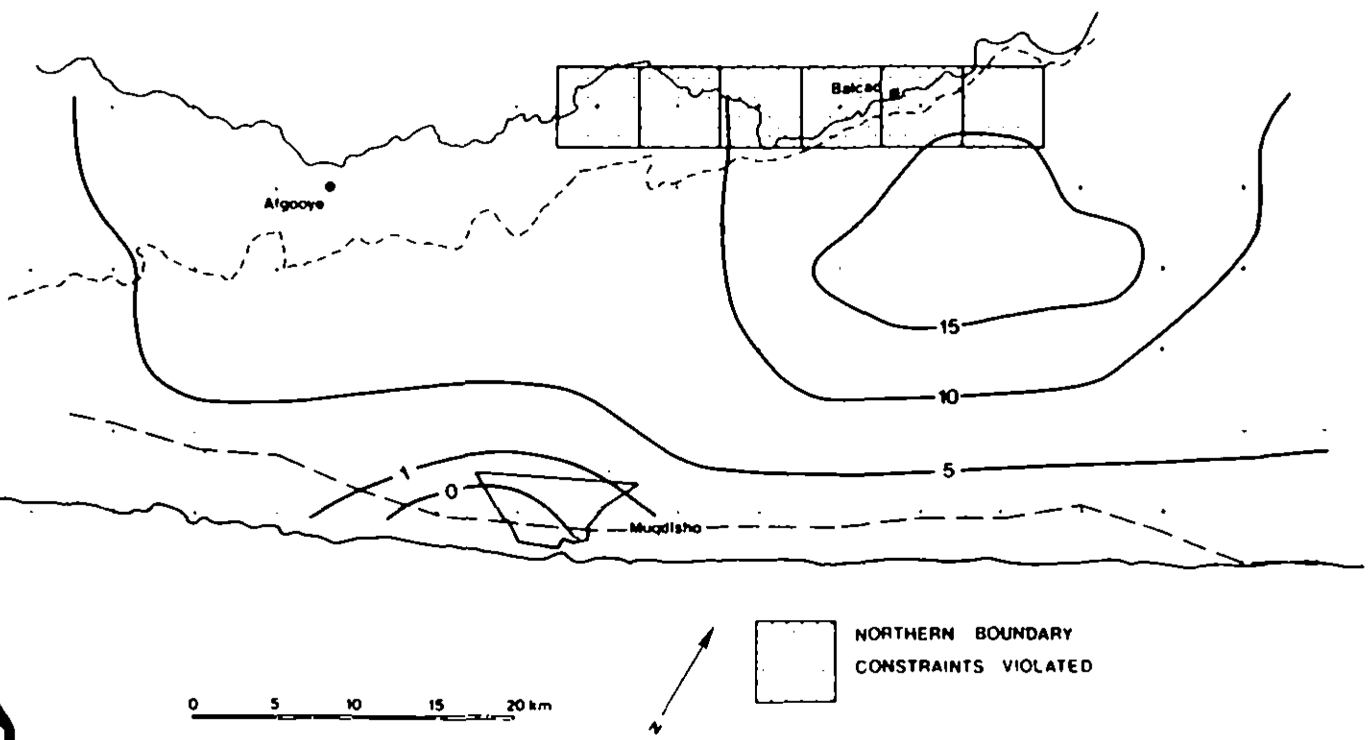


Figure F·6

G. STAGE III WELLFIELD DESIGN

APPENDIX G STAGE III WELLFIELD DESIGN

The proposed Stage III wellfield is located in the vicinity of exploratory borehole E04. The area covers four management model nodes each five kilometres square with E04 at the centre. Aquifer transmissivity in he range 1800 to 1990 m^2/d and a storage coefficient of 4 per cent were used in the model. For the wellfield simulations a transmissivity value of 1800 m^2/d was adopted with the storage at 4 per cent. The elevation of the water is about + 30 m above sea level while the total saturated thickness of the aquifer is between 135 and 155 metres.

For the management model studies a maximum abstraction of 10 million m^3/yr per node was selected to reduce potentially excessive drawdowns. As the abstraction rate per well of 60 $m^3/hour$ has been used in both the Balcad Road and Afgooye Road wellfields we have kept to this figure. The simulation was run for the year 2020 assuming the phased build up of abstraction as shown in Table F.1; these nodal abstraction rates and distribution are the same as those used in the management model.

The seven simulations of the wellfield model, which is based on Papadopulos and Cooper solutions, were run using the four configurations shown in Figure G.1. With the exception of run 6 the distances between wells was 300 m which, from our previous studies for the Afgooye Road wellfield, we concluded was the optimum spacing in the sand aquifer.

Apart from configuration A similar drawdowns were predicted with D giving the best results, Table G.2 summarises the results from each simulation. The orientation of the lines in configurations B to D have been altered so that they are approximately parallel to the river which is the main source of recharge.

We decided that configuration D was the best one and ran three additional simulations based on that design. As some of the surrounding nodes in the management model used lower transmissivity values run 5 was carried out. This was identical to run 4 except that the transmissivity was reduced to 1400 m^2/d; although this increased the drawdowns they were still reasonably acceptable.

TABLE G.1 Abstraction Distribution

	Total Demand (thousand m^3/yr)	Wells/Node 1	2	3	4	Total No. of wells
1990	2120		3	2		5
91	4291		4	5		9
92	6638		7	6		13
93	9175		9	9		18
94	11917		11	12		23
95	14881		14	15		29
96	17939		17	18	-	35
97	21223		17	18	6	41
98	24782	-	17	18	13	48
99	28604	7	17	18	13	55
2000	32722	15	17	18	13	63

TABLE G.2 Wellfield Simulation Results for 2020

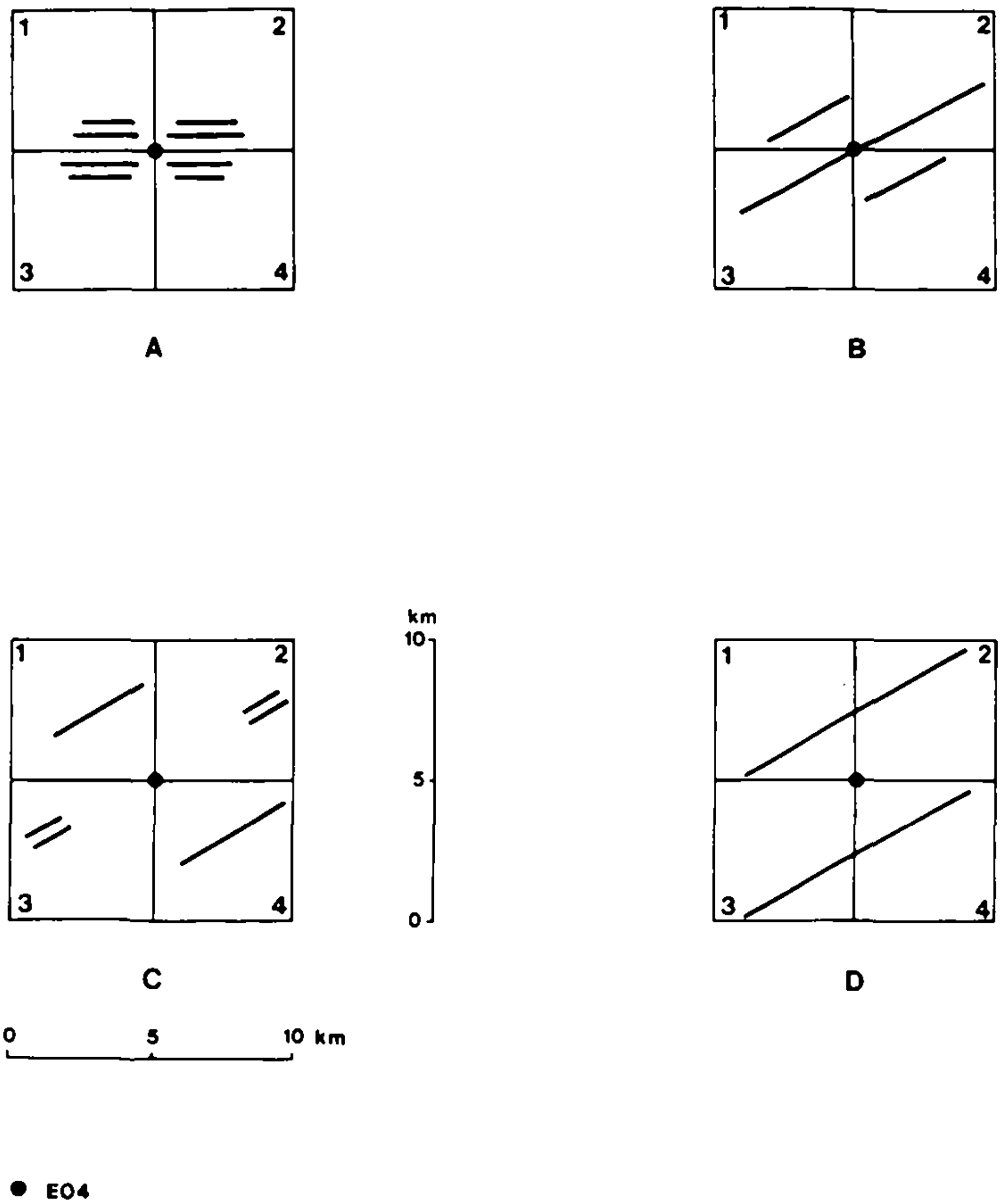
Run No.	No. of Wells	Abstraction per well	Drawdown* Min	Max	Mean
	63	60	21.5	25.9	24.2
2	63	60	16.4	21.9	19.8
3	63	60	16.8	19.3	18.1
4	63	60	14.9	19.3	18.1
5	63	60	17.9	23.5	22.0 **
6	32	120	16.2	20.4	19.3 ***
7	32	120	20.3	23.4	22.4

* No partial penetration correction applied, wells assumed to be 100% efficient

** Transmissivity of 1400 m^2/d used (all other runs 1800 m^2/d used)

*** Well spacing of 600 m (all other runs 300 m used)

Stage III possible wellfield configurations



In an attempt to reduce the areal extent of the wellfield we doubled the rate of abstraction per well and reduced the number of wells. We found that the distance between adjacent wells had to be doubled, keeping the overall dimensions of the wellfield the same, to avoid too large a drawdown.

Although we have briefly investigated the possiblity of increasing the rate of abstraction from 60 m^3/hr to 120 m^3/hr there would appear to be no significant decrease in the overall size of the wellfield. However, hydrogeologically, the aquifer should be able to sustain the higher abstraction rate but we would need to carry out further tests in the area to determine whether the aquifer is as uniform as we believe it to be.

The design of the production wells in the Afgooye Road wellfield has shown that the yield drawdown characteristics are satisfactory and that the wells are sand free. As the sequence found in exploratory borehole E04 is not significantly different from elsewhere in the sand aquifer we feel that there is no reason to alter the design of either the screen size or the filter pack grading.

The chemical analysis of the airlift sample taken from E04 shows the water quality to be acceptable. The proposed wellfield lies within the same tongue of good quality recharge water. However from our experience of the Afgooye Road wellfield it is possible for the quality to alter quite considerably within relatively short distances and thus we would recommend that the variation in quality be carefully monitored during the construction phase.

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